DOCUMENT RESUME

ED 267 077 TM 850 738

AUTHOR Hilton, Thomas L.
TITLE National Changes in Spatial-Visual Ability from 1960 to 1980.
INSTITUTION Educational Testing Service, Princeton, N.J.
REPORT NO ETS-RR-85-27
PUB DATE Jun 85
NOTE 22p.
PUB TYPE Reports - Research/Technical (143)

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS *Educational Trends; Grade 12; High Schools; *High School Seniors; Individual Differences; *Longitudinal Studies; National Surveys; Reading Skills; Reading Tests; Sex Differences; *Spatial Ability; *Visualization; Visual Measures
IDENTIFIERS *High School and Beyond (NCES); *Project TALENT

ABSTRACT

In both 1960 and 1980, the same test of spatial-visual ability was given to national probability samples of high school seniors in the United States. The students in 1960 were participants in Project TALENT and in 1980 were participants in "High School and Beyond." In addition, a reading comprehension test was given to the 1960 students that subsequently was equated to a similar reading test given to the 1980 seniors. In 1960 the males had substantially higher scores in visualization and slightly higher scores in reading. Between 1960 and 1980 all means scores declined but substantially more so in visualization. However, the gap between males and females narrowed, particularly in visualization. In the absence of a clear explanation, the report attributes the general decline primarily to less student attrition in 1980 and the differential decline to convergence in the experiences of males and females. (Author)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

RR-85-27

RESEARCH REPORT

ED267077

NATIONAL CHANGES IN SPATIAL-VISUAL ABILITY FROM 1960 TO 1980

Thomas L. Hilton

"PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY

P. Feldmesser

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

U.S. DEPARTMENT OF EDUCATION
NATIONAL INSTITUTE OF EDUCATION
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

☒ This document has been reproduced as received from the person or organization originating it.

☐ Minor changes have been made to improve reproduction quality.

• Points of view or opinions stated in this document do not necessarily represent official NIE position or policy.

TM 850 138

Educational Testing Service
Princeton, New Jersey
June 1985

National Changes in Spatial-Visual Ability from 1960 to 1980

Thomas L. Hilton

Educational Testing Service
Princeton, New Jersey
June 1985

Copyright © 1985. Educational Testing Service. All rights reserved.

Abstract

In both 1960 and 1980, the same test of spatial-visual ability was given to national probability samples of high school seniors in the United States. The students in 1960 were participants in Project TALENT and in 1980 were participants in High School and Beyond. In addition, a reading comprehension test was given to the 1960 students that subsequently was equated to a similar reading test given to the 1980 seniors. In 1960 the males had substantially higher scores in visualization and slightly higher scores in reading. Between 1960 and 1980 all means scores declined but substantially more so in visualization. However, the gap between males and females narrowed, particularly in visualization. In the absence of a clear explanation, the author attributes the general decline primarily to less student attrition in 1980 and the differential decline to convergence in the experiences of males and females.

National Changes in Spatial-Visual Ability from 1960 to 1980

Thomas L. Hilton

Educational Testing Services

In 1960 a 16-item test of spatial relations was given to a national sample of high school seniors in Project TALENT. Twenty years later the same test was given to a national sample of seniors in High School and Beyond (HS&B), the second cohort of national longitudinal studies sponsored by the National Center for Education Statistics. These data permitted the investigation of three key questions:

1. Did the mean spatial-visual relations skills of high school seniors change in this 20 year period?
2. Did the relative standing of males and females change?
3. Did the mean spatial-visual relations skills of high school seniors change more or less than mean reading skills?

Students of differential psychology learn early in their training that males have higher scores than females in spatial relations (Anastasi, 1965). There is debate, however, about the onset of this differential and, more so, what the causality is. Maccoby and Jacklin report that "On the whole, [visual-spatial tests] show no sex differences until adolescence..." (1974, p. 94). The same authors concluded that there is a genetically sex-linked component in spatial ability but that how the component functions is unclear. Furthermore, the authors point out that:

The author is indebted to Jerilee Grandy and Issac Bejar for their review of a draft of this paper.

> "The existence of a sex-linked genetic determiner of spatial ability does not imply that visual-spatial skills are unlearned. The specific skills involved in the manifestation of this ability improve with practice. Futhermore, cross-cultural work indicates that the sex difference can be either large or small, or may even disappear, depending upon cultural conditions affecting the rearing of the two sexes. Where women are subjugated, their visual-spatial skills are poor relative to those of men. Where both sexes are allowed independence early in life, both sexes have good visual-spatial skills (p. 361)."

Why gender differences in spatial-visual skills should emerge in adolescence—assuming that it does—is not clear. Some authors have offered physiological hypotheses involving the hormonal system (Broverman et al., 1968). Others have linked the phenomenon to the development of cerebral lateralization (Sherman, 1971). A less complicated hypothesis would be that the emergence of male superiority represents the cumulative impact on the part of the males of years of experience with games, toys, tools, and equipment and enrollment in school courses conducive to the development of spatial-visual skills, and further that the gradual onset of superiority sometimes has not been detected because the required long-term longitudinal studies with sufficiently sensitive measures were not conducted.

In view of the research literature, what were the expectations of the author in regard to the three questions listed above? First, in regard to mean change for the total sample since 1960, it was expected

that, on balance, there would be little change. To the extent that the level of skill represents genetic factors, there should be no change and to the extent that the skill in question reflected experiential factors there would be a trade-off. Casual observation suggests that fewer contemporary students enroll in mechanical drawing and advanced math courses contributing to spatial-visual skills but, on the other hand, that more young people--both male and female--are exposed to mechanical and electronic toys, games, and gadgetry that may lead to spatial skills.

Second, as for the male-female difference, the author's clear expectation was that there would be a convergence of difference as a result of a convergence of sex roles, cultural expectations, and the experiences of males and females both in school and out of school from 1960 to 1980.

Third, the author expected that reading skills would display more decline than spatial-visual skills simply because reading scores declined substantially from 1960 to 1972 (Beaton, Hilton, & Schrader, 1977) and continued to decline from 1972 to 1980 (Hilton, 1985).

Method

In 1960, a test entitled "Visualization in Three Dimensions" (V3D) was included in a battery of 15 tests given to approximately 400,000 high school students as part of Project TALENT (Flanagan, 1960). The cover page of the test is shown in Figure 1. Each of the 16 items of the test required the subject to select, from five solid objects depicted, the one object that could be made by folding or twisting the flat piece shown as the stem of the item. The ETS Factor Kit categorizes the Surface Development Test (VZ-3), which is

Figure 1

Cover Page of Visualization in Three Dimensions Test

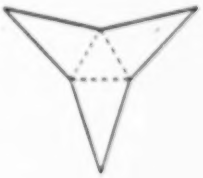
SECTION 6
VISUALIZATION IN THREE DIMENSIONS

Time—9 minutes

Directions: Each problem in this test has a drawing of a flat piece of metal at the left. At the right are shown five objects, only one of which might be made by folding the flat piece of metal along the dotted line. You are to pick out the one of these five objects which shows just how the piece of flat metal will look when it is folded at the dotted lines. When it is folded, no piece of metal overlaps any other piece, or is enclosed inside the object. On this test your score will be the number of correct answers.

Now look at example 1 below.

Example 1:



Sample Question

Of the five objects shown, only E could be made from the flat piece shown at the left by folding it at each of the dotted lines. E shows how the flat piece would look after being folded. Therefore, oval E would be marked.

Remember, all folds are indicated by dotted lines; the solid lines show the cuts in the piece, and parts are not folded inside of other parts of any objects (in other words, there is no overlapping).

DO NOT TURN THIS PAGE UNTIL YOU ARE TOLD TO DO SO.

highly similar, as a measure of visualization, defined as "the ability to manipulate or transform the image of spatial patterns into other arrangements" (Ekstrom et al., 1976, p. 173).

The authors add that "The visualization and spatial orientation factors are similar but visualization requires that the figure be mentally restructured into components for manipulation while the figure is manipulated in spatial orientation." Accordingly, we will refer to the skill measured by the V3D test as visualization in the balance of this article.

The students in 1960 attended the public and private high schools that participated in Project TALENT. The schools were randomly sampled to be representative of all public, parochial, and private schools in the United States that contained grade 12. Student participation in the data collection was required. The results to be reported were based on a subsample of the total TALENT sample which was weighted to be representative of all public and private school students in the United States. Classroom teachers were trained by Project TALENT local coordinators to conduct the data collection.

In 1980, the identical Project TALENT test was included in a battery of six tests given to the high school seniors participating in HS&B. The students attended high schools which were randomly selected to be representative of all public, parochial, and private secondary schools in the United States. In each school, 36 seniors and 36 sophomores were randomly selected for participation, which was optional. Useable test results were obtained from an average of approximately 28 seniors in each school. Approximately 12% of the sampled students were absent on both the survey day and the make-up days, 3% refused to participate and 3% of the cases were unuseable because critical survey material was missing (NORC, 1983, p. 14).

Reading. Both the 1960 and 1980 batteries included tests of reading speed and comprehension but the format and content of the test differed. However, as part of the score decline study conducted by Beaton, Hilton, & Schrader (1977), the reading tests given in 1960 and the 1972 National Longitudinal Study (Hilton et al., 1973) were equated and, since the 1972 NLS test was identical to the 1980 HS&B test, it was possible to put the 1960 and 1980 reading scores on the same scale. Thus, comparable reading scores were obtainable for the 1960 and 1980 seniors. Because of substantial differences between the items and administrations of the mathematics items in 1960 and 1972, it was not possible to obtain comparable mathematics scores.

Results

The first results, shown in Table 1, can be succinctly summarized: The high school seniors in 1980 performed on the V3D test at precisely the same level as the 1960 freshmen. From 1960 to 1980, the mean for the males declined by 1.6 raw score points or .48 standard deviations (SDs) and the mean for the females declined by 1.2 raw score points or .38 SDs. The mean for the total sample declined by 1.4 or .44 SDs. One raw score point is equivalent to one item answered correctly. In one sense, a decline of 1.4 raw score points does not represent a large quantum of learning. But considered in light of the fact that the growth from Grade 9 to Grade 12 on most academic achievement tests is about 2 raw score points (Shaycoft, 1967, Table 4-9), the decline is nontrivial.

As for the second question concerning mean differences between males and females, the discrepancy was 1.2 points or .36 SDs in 1960 and .8 points or .26 SDs in 1980. Thus, we can say that the raw score difference between males and females decreased in the twenty-year period by one-third.

Table 1

Means ($\bar{X}$) and Standard Deviations (SD) of Visualization in Three Dimensions (V3D) Scores in 1960 and 1980

	1960 Grade				1980 Grade		Effect
	9	10	11	12	12	1980-1960	Size[1]
Males							
Sample N	3,921	3,876	3,483	2,946	10,977		
Population Est.[2]	822	813	735	619	1,180		
$\bar{X}$	8.1	8.7	9.3	9.7	8.1	-1.6	.48
SD	3.3	3.3	3.4	3.4	3.3	- .1	
Females							
Sample N	4,012	3,914	3,658	3,302	12,055		
Population Est.[2]	827	820	761	678	1,295		
$\bar{X}$	7.3	7.8	8.2	8.5	7.3	-1.2	.38
SD	2.9	3.0	3.0	3.2	2.9	- .3	
Total							
Sample N	7,933	7,790	7,141	6,248	23,865		
Population Est.[2]	1,649	1,634	1,494	1,298	2,561[3]		
$\bar{X}$	7.7	8.2	8.7	9.1	7.7	-1.4	.44
SD	3.1	3.2	3.3	3.3	3.1	- .2	

[1] Effect size is difference divided by the pooled standard deviation.

[2] In thousands.

[3] In 1980 the sum of the population estimates for males and females does not equal the total population estimate since 3% of the sample did not identify their sex.

Notice that for the 1960 sample the difference between the 9th grade males and females was .8 scale points or .26 SDs and between the seniors was 1.2 points or .36 SDs. Since these are cross-sectional results, they reflect both school attrition and individual growth. However, longitudinal results were obtained in a later follow-up of the 9th graders (Shaycoft, 1967). These results show a gap of .24 SDs at the 9th grade and .42 SDs at the 12th grade, with males higher at both grades. Thus, the males in 1960 gained appreciably more in visualization than the females during high school.

The third question was whether visualization skill declined more or less than reading skill. As shown in Table 2 and Figure 2, the reading score of the males declined 1.7 points or .32 SDs and the females declined 1.6 points or.32 SDs. The difference between the men and women was .1 points in 1960 and 0 points in 1980. Thus, there was essentially no difference between the males and the females in reading in either 1960 or 1980 but both declined by about one-third of an SD in the time period. Considering that the males declined by .48 SDs in visualization and the females by .38 SDs, we can say that the decline in visualization was substantially more than the decline in reading; specifically, the decline in SD units was 33% more for the males and 16% more for the females.

Discussion

Total Sample Differences

Possible artifacts. Why the means in visualization for the total sample should decline so dramatically from 1960 to 1980 is not clear. There are several possible explanations, the first of which is that the result

Table 2

Means ($\bar{X}$) and Standard Deviations (SD) of Reading Scores in 1960 and 1980

	1960[1] Grade 12	1980[3] Grade 12	1980-1960	Effect Size[2]
Males				
Sample N	9,938	11,362		
Population Est.[4]	910	1,216		
$\bar{X}$	10.6	8.9	-1.7	.32
SD	5.2	5.3	.1	
Females				
Sample N	10,421	12,631		
Population Est.[4]	954	1,353		
$\bar{X}$	10.5	8.9	-1.6	.32
SD	5.0	5.0	0	
Total				
Sample N	20,359	24,892		
Population Est.[4]	1,864	2,661		
$\bar{X}$	10.5	8.8	-1.7	.33
SD	5.1	5.2	.1	

[1] Source: Beaton, Hilton, and Schrader, 1977.

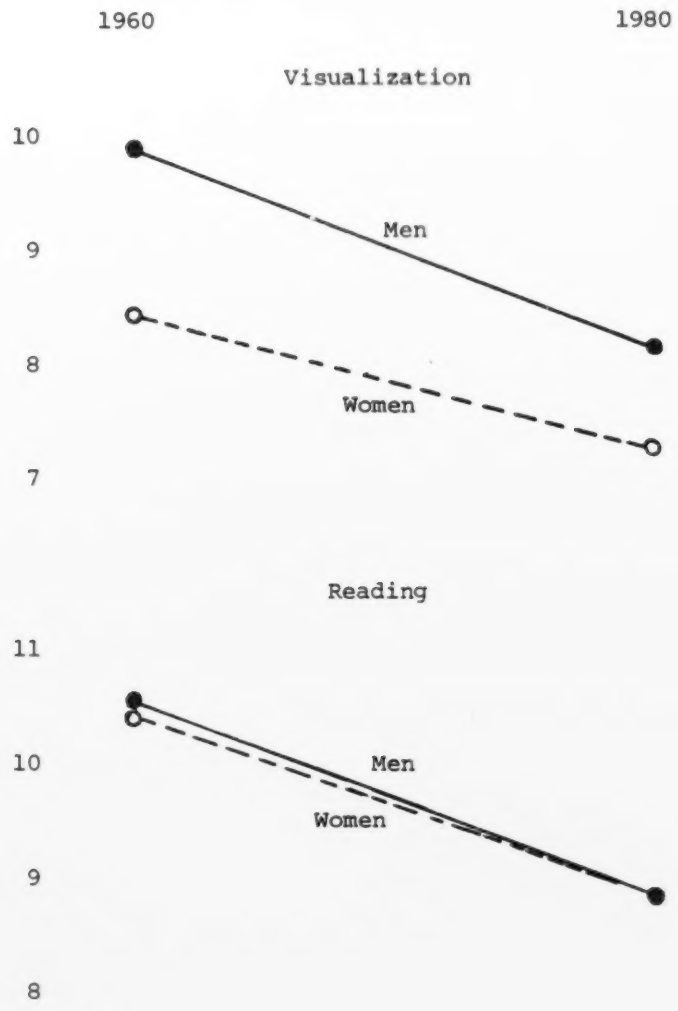
[2] Effect size is difference divided by the pooled standard deviation.

[3] Source: Hilton, 1985.

[4] In thousands.

Figure 2

Declines in Visualization and Reading for Men and Women



represents an artifact of the survey design and data collection conditions. Examination of the relevant research reports suggests, however, that this is not likely to be the case. Both samples were national probability samples weighted to correct for sampling and for incomplete data. The method of administering the tests differed, but in ways which this author would regard as minor. If anything, the differences would favor the 1980 students: the 1960 testing was towards the end of two full days of testing, whereas the 1980 testing was completed within two hours. One would think that fatigue and boredom might have had a negative effect on the TALENT students.

The 1980 students were told that their score would be the number of items which they answered correctly—instructions that might have encouraged guessing. On the other hand, the 1960 students were not told how their score would be computed. The scores reported here are the number of items answered correctly, for both samples. Again, this difference would have favored the 1980 sample, if at all.

Another position would be that all students in 1960 were less tested and more compliant and cooperative and, thus, more motivated to do well in testing for research purposes. But possibly offsetting this is the fact that the 1980 students were more self-selected to participate (scores were obtained for only 28 out of the 36 students in each senior class sample). What the net effect of all these factors may have been is impossible to say. The conservative position is that they balanced each other.

Population changes. A second possible explanation concerns the populations of students sampled. 67% of the relevant age cohort completed high school in 1960 whereas 74% of the 1980 age cohort completed high school. (The number in the relevant age cohort was defined by NCES as the average of

the number of individuals who were 17 or 18 in age in the year in question.) Assuming that the students who dropped out had lower visualization and reading scores, the higher dropout rate of the 1960 cohort would to some extent result in higher scores for that cohort. In other words, the 1960 seniors represented a more selected group that could be expected to have higher scores in both visualization and in reading. Beaton, Hilton, & Schrader concluded that this phenomenon was the main cause of the decline in reading scores from 1960 to 1972 (Beaton et al., 1977).

Racial/ethnic composition. Another possible explanation is suggested by the change in the racial/ethnic composition of the two samples. As shown in Table 3, the V3D test means are substantially lower for Black students and Hispanic students than for White students. Since the proportion of Black students and Hispanic students increased substantially from 1960 to 1980, the increase could account for a share, possibly large, of the observed decline. This change in racial/ethnic composition, however, is confounded with changes in socioeconomic status, retention rates, and other possible causative demographic agents, the full analysis of which is beyond the scope of this paper. The possibility exists, nonetheless, that the general decline in both reading and visualization scores is entirely attributable to these demographic changes. However, in a study of score change from 1972 to 1980, racial/ethnic changes accounted for only a small share of the total change when student behaviors, school characteristics, and home support variables were held constant by analysis of covariance (Hilton, 1985).

Curriculum changes. Several studies recently have provided evidence of the strong effect of enrollment in classroom instruction on performance on tests in related areas (see, for example, Wiley & Harnischfeger,1974). It

Table 3

Means ($\bar{X}$) and Standard Deviations (SD) of Visualization in Three Dimensions (V3D) Scores for Whites, Blacks, and Hispanics[1] in 1980

Subpopulation	Sample N	Population Estimate	($\bar{X}$)	SD
Whites	17,264	2,046,000	8.0	3.1
Blacks	2,917	261,000	5.8	2.6
Hispanics	2,601	147,000	6.7	2.8
Total	23,865	2,561,000	7.7	3.1

[1]The Hispanic category includes Mexican-American, Cuban, Puerto Rican, and other Latin American.

seems likely that exposure to certain subjects, such as solid geometry, trigonometry, and mechanical drawing, would enhance performance on the V3D test and if there was more exposure for the 1960 sample—which is likely—then the difference in test performance might be to some extent explained by curriculum changes from 1960 to 1980.

Sex distribution. Another possibility concerns possible changes in the sex distribution from 1960 to 1980. This is difficult to estimate because of missing data in regard to sex identification in the 1980 sample but at most it appears that this change would account for only a small fraction of the observed decline.

In any case there seems to be several possible reasons for the substantial decline in spatial-visual relations. But why the visualization scores should decline substantially more than the reading scores is not explained by the available data. In any future research in this area, the author would give priority to the hypothesis that the differential decline is related to decreases in enrollments in high school courses conducive to the development of spatial-visual skills.

The more puzzling and significant finding is the relative stability from 1960 to 1980 of the higher mean scores for the males. How we interpret this stability depends on what assumptions we make about differential exposure of the sexes to experiences conducive to the development of visualization skills in 1960 as compared to 1980. Is a convergence of one-third consistent with changes in exposure or not? The author's interpretation of these results is that the decrease in sex differences does reflect a trend towards uniformity in experience but that substantial differences in the informal and formal educational experience of the sexes remain and, further, that there is no need

to hypothesize genetic constraints on the development of visualization skill by males and females. What is clear, however, is that a substantial gap between the sexes in visualization skill existed in 1960, that the skill of both males and females declined appreciably from 1960 to 1980, and that a large gap still existed in 1980.

References

Anastasi, A. (Ed.). (1965). Individual differences. New York: Wiley.

Beaton, A. E., Hilton, T. L., & Schrader, W. B. (1977). Changes in the verbal abilities of high school seniors, college entrants, and SAT candidates between 1960 and 1972. New York: College Entrance Examination Board.

Broverman, D. M., Klaiber, E. L., Kabayashi, Y., & Vogel, W. (1968). Roles of activation and inhibition in sex differences in cognitive abilities. Psychological Review, 75, 23-50.

Ekstrom, R. B., French, J. W., & Harman, H. H. (with Dermen, D.). (1976). Manual for kit of factor-referenced cognitive tests, 1976. Princeton, NJ: Educational Testing Service.

Flanagan, J. C., Dailey, J. T., Shaycoft, M. F., Gorham, W. A., Orr, D. B., & Goldberg, I. (1960). Designing the study. (Technical Report to the U.S. Office, Cooperative Research Project No. 566). Pittsburgh: Project TALENT Office, University of Pittsburgh.

Hilton, T. L., & Rhett, H. (1973). The base-year survey of the national longitudinal study of the high school class of 1972. (Final report to the U.S. Department of Health, Education, and Welfare, National Center for Educational Statistics, Contract No. OEC-0-72-0903) Princeton, NJ: Educational Testing Service.

Hilton, T. L. (1985). Changes in student achievement. Paper presented at the annual meeting of AERA, Chicago.

Maccoby, E. E., & Jacklin, C. N. (1974). The psychology of sex differences. Stanford, California: Stanford University Press.

National Opinion Research Center. (1983). High School and Beyond, 1980 senior cohort, First follow-up (1982), Data file user's manual. Washington, DC: National Center for Education Statistics.

Shaycoft, M. (1967). Project TALENT-The High School Years: Growth in cognitive skills. (Interim Report 3 to the U.S. Office of Education, Cooperative Research Project No. 3051) Pittsburgh: Project TALENT Office; American Institutes of Research.

Sherman, J. A. (1971). On the psychology of women. Springfield, IL: Charles C. Thomas.

Wiley, D. E., & Harnischfeger, A. (1974). Explosion of a myth: Quantity of schooling and exposure to instruction, major educational vehicles. Educational Researcher, 3(4), 7-11.